Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

B71 12005

date: December 6, 1971

to: Distribution

from: G. M. Anderson

subject: S-192 Data Problem, A Summary
Case 620

ABSTRACT

Acceptance testing of the S-192 Multispectral Scanner showed that the design permits a variable number of words in the data frame. Later, during the study of this problem, it was further found that the last bit of the last word is variable in 1/12 bit increments. Ground processing equipment cannot cope with these variations as presently designed and some changes are necessary.

The variable bit problem probably requires a change in the flight hardware. Options to fix the problem of a variable number of words in the data frame include both ground and flight alternatives. MSC is studying the problems and solutions.

(NASA-CR-125364) S-192 DATA PROBLEM, A SUMMARY (Bellcomm, Inc.) 13 p

N79-72519

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MEMORANDUM FOR FILE

Introduction

During acceptance testing of S-192 hardware, September 17, 1971, it was discovered that the equipment was producing a variable length data frame. A data frame, as it appears on each channel of the EREP tape recorder, consists of 1280 words, 8 bits/word. A variation in the number of words per frame was the condition experienced. Since ground equipment planned for use with S-192 is designed for 1280 words with little or no tolerance, frame length variation is a condition requiring repair.

Recently, a related problem has been identified. Not only does the data frame contain a variable number of words, but the last bit of the last word can, and generally will, be of variable length. This condition alters the phase of the Miller clock frequency for the tape recorder with subsequent loss of synchronization on playback in the ground equipment.

This memorandum describes these problems and the several alternatives under study to resolve them.

Simplified Schematic

Figure 1 shows, in simplified form suitable for present purposes, the major elements of the flight equipment.

Fourteen channels, with one channel inactive, transmit analogue data from the scanner to the analogue to digital converters of the Digital Electronic Assembly (DEA). For historical reasons the 14 analogue channels are converted to 22 digital channels by sampling 8 channels at twice the rate of the other 6.

The buffer memory is divided into two parts A and B. Read and write operations cannot be performed simultaneously in either parts A or B. The procedure used is to write A and read B and then interchange. Data from 3 of the channels sampled at the low rate plus all 8 channels sampled at the high rate are written into memory A. On the next write cycle, data from the other 3 channels sampled at the low rate, plus again all 8 channels sampled at the high rate are written into memory B.

The breakout box, shown dashed in Figure 1, is not flight equipment. Its use in testing is described later.

Origin of the Problem

Timing for S-192 is derived from a crystal oscillator with a frequency of 11.648063 MHz. A countdown chain derives all the required lower frequencies from this source.

The scanning system used is mechanical. A four pole synchronous motor drives a mirror that effects the required cross track scan of the ground target. The motor frequency, derived from the crystal oscillator, is 189.584 Hz. The nominal frequency of rotation is therefore 94.792 Hz. To a 6% approximation, the period of the rotation is 0.01 seconds.

Once each rotation, an optical encoder on the motor shaft produces a synchronizing pulse. Detection of this pulse by the DEA is the signal to begin a new data frame.

The difficulty is that synchronous motors run at constant average speed, not constant instantaneous speed. Variations in the arrival of the synchronizing pulse, measured against the superior stability of the crystal oscillator, can and do occur. These variations extend or shorten the 1280 word frame by an amount proportional to the time error in the synchronizing pulse.

For ground testing of S-192 an auxiliary motor is required. It is directly coupled mechanically to the shaft of the flight equipment motor. The reason for the additional mechanical power is that the flight motor is designed for vacuum conditions and it cannot develop rated speed at one atmosphere. It is not planned to use vacuum test conditions for other reasons.

Measurements of the variation in the time of one revolution for the worst case show

Ground Test

MMC Observation: ±42 bits (5 1/4 words, 43 microseconds)

Flight Conditions (Simulated)

HRC Observation: ±10 bits (1 1/4 words, 10 microseconds)

Maximum deviation of scan sync from fixed time reference - ±185 microseconds

Data Frame

A representative data frame, for Channel No. 1, as recorded on the EREP tape recorder, is shown in Figure 2. The frame of 1280 words is divided into ten sub-frames of 128 words each. The first sub-frame starts with four synchronizing words followed by 18 words of calibration data. Data begin with word 23 and continue through word 128.

Subsequent sub-frames start with two synchronizing words followed by 126 data words.

The other 21 channels are similar. All data frames are stored in the buffer memory and read out and recorded on the EREP tape recorder.

Data Word - Miller Encoding and Decoding

A representative word containing 8 bits of NRZ code is shown in Figure 3. These words constitute the data stream recorded on the EREP tape recorder. The EREP recorder uses a Miller code that requires a clock with a frequency twice that of the data stream. The clock frequency is not recorded but is derived in the ground equipment and used to convert the Miller code back to the NRZ code.

As shown in Figure 3, the arrival of the synchronizing pulse reinitializes the data stream. A bit of an NRZ data word, of duration 1.03 microseconds, can be divided in 12 parts or 89 nanoseconds. This process causes a variation in the phase of the Miller clock, as shown in Figure 3, with the result that the clock in the ground station has to be resynchronized. Ampex estimates that approximately 50 bits, or about 6 words, are required for resynchronization. That means all four main frame synchronizing words are lost and consequently all output data are lost.

Ground Equipment - Problems and Fixes

The ground equipments planned for use with S-192 are designed for 1280 word frames. The variable frame problem can be fixed on the ground by redesign of the ground logic, in each equipment, to initiate a new frame on the arrival of the 4 synchronizing words at the start of the frame. A suitable tolerance on the arrival time of this sequence must be provided to encompass the expected motor variation.

Although one method to remedy the variable bit problem with the ground equipment has been suggested, the consensus is that the flight equipment should be fixed.

Ampex FR 1928 Ground Tape Playback

This equipment is used to playback on the ground the tapes recorded on the AR 728 flight recorder. The Miller decoding is accomplished in this unit. Present opinion holds, as stated, that the variable bit problem should be fixed in the flight equipment. That method makes changes to the FR 1928 unnecessary.

DQLS - Denver Quick Look Data Processing - MMC

FTS S/N002

FTS (Functional Test Set) is used for integration testing. Two possible options are available to permit this equipment to function. These are:

a) Redesign to permit variation in the arrival of the frame synchronization signal.

b) Insert a black box in the flight equipment (breakout box), shown dashed in Figure 1, to interrupt the synchronizing pulse and develop a pseudo-synchonizing pulse at the proper time. This gives fixed length frames but clearly prejudices line to line registration in the recording. The merit of this method is it is simple and it permits the testing to proceed on schedule. This option is being exercized.

GPL - General Purpose Laboratory

Equipment in the GPL can reportedly be programmed to process single channel variable frame data. This can be done in time to support the integration testing.

DRA - Data Reformatter Assembly

The DRA can accept a subframe length of 128,8 bit words, ±6 words in increments of one word. Variable bits results in the loss of 3 subframes.

Modification of the DRA logic is required if the variable frame problem is to be resolved by changes in the ground equipment.

DAS - Data Analysis System

The DAS has several functions:

1. Produce Computer Compatible Tape (CCT), 800 bit/in at 150 in/sec, that can be used with tape equipment from any general purpose digital computer.

2. Produce film output

3. Produce cathode ray tube displays.

Two DAS equipments are available at MSC, one built by Aerojet and one by Bendix. The aerojet unit is planned for Skylab although the Bendix unit could be used if desired.

Presently the DAS is designed to accept only subframes of 128, 8 bit words. It does use the main frame synchronizing event.

Modification of this equipment is required if the variable frame problem is to be resolved in the ground equipment.

Flight Equipment Fix

HRC has submitted an ECP which can solve the frame variation and variable bit problems in the flight equipment. There is some ground system impact if full system spatial resolution is to be retained.

Figure 4 shows the present design timing for the memory. The cycle is initiated on the arrival of a synchronizing pulse from the optical encoder. Whether or not the prior output data frame is complete, two things happen on receipt of the synchronizing pulse:

1) A new output data frame is initiated, terminating thereby reading of stored data from the prior frame.

2) Writing of sensor data from the new scan line is initiated.

The new proposal would modify the present arrangement. On the arrival of the synchronizing pulse:

1) Readout of sensor data stored from the prior scan line continues, if not completed already, on the read cycle until the frame is complete.

2) Writing of sensor data is initiated at the first write opportunity following the synchronizing pulse.

3) Start of the new output frame is initiated at the completion of reading the prior frame data.

This concept makes use of the fact that the output frame (Figure 2) does not require sensor data for 22 words (176 bits) after frame initiation. This provides a time margin for the case when the synchronizing pulse is late.* When the synchronizing pulse is early there is no difficulty since the data words are available before they are required. Since the synchronous motor does run at constant average speed, the synchronizing pulse on a long time average basis is on time. If the maximum deviation of the synchronizing pulse is less than the equivalent time of 176 bits this buffering arrangement, which ingeniously requires no additional buffer but makes use of that already available, should adequately deal with pulse arrival variations.

The disadvantage is that writing of sensor data must be delayed slightly, since the read-write cycle must be continuous, to preserve the option to continue reading data from the prior frame. Since the start of the write cycle for new data must begin with the A memory, Figure 4, the maximum delay appears to be equivalent to 1 resolution element (1 reselm=260 ft.). Apparently only, since HRC claims the figure is 0.6 reselms.

In order to avoid the loss in line to line registration that this delay entails, it is proposed to record the delay with housekeeping data. Ground data processing could then adjust the line to line registration and remove the effect of the delay. It appears necessary to buffer the data during ground processing to compensate the delay. Buffering should not exceed 1 or 2 words per channel.

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*If this margin is too small the frame format will have to be changed to delay the start of reading data to a later time in the frame.

This proposal resolves simultaneously the variable frame and variable bit problems. There is a variation of this method that is less complex and that fixes only the variable bit problem. In this option the start of a new frame is initiated at the next bit cycle thus producing a continuous NRZ bit stream and a continuous Miller clock. This option does produce variable word frames and the ground equipment modifications to accommodate these variations are required.

It is understood that HRC claims this latter option will take longer and cost as much since they already are working on the first method.

Summary

Integration Testing at MMC

1. A breakout box is being procured to permit FTS (integration test equipment) to be utilized. Advantage is simplicity and minimum schedule impact. Disadvantage is system resolution is greatly degraded.

2. General Purpose Laboratory can be programmed for use. Preserves resolution of system at greater expense.

Ground Equipment Fix

1. Modify equipment at MSC, DRA and DAS, to accept variable frame data.

Flight Equipment Fix

1. Modify digital electronics to provide fixed frame output.

2. Record delay in recording data at start of scan line.

3. Provide for buffering of data in ground processing to remove effect of the delay. This provision is only required to achieve full system resolution. Without buffering, resolution is degraded by a maximum of 1.0 reselms.

Acknowledgement

Information contained in this summary was obtained through the help of Richard Glover, James Booker, Jesse Kersh and William Henseley of MSC. Charles Williams provided access to the specialists at MSC and reviewed a first draft of this memorandum.

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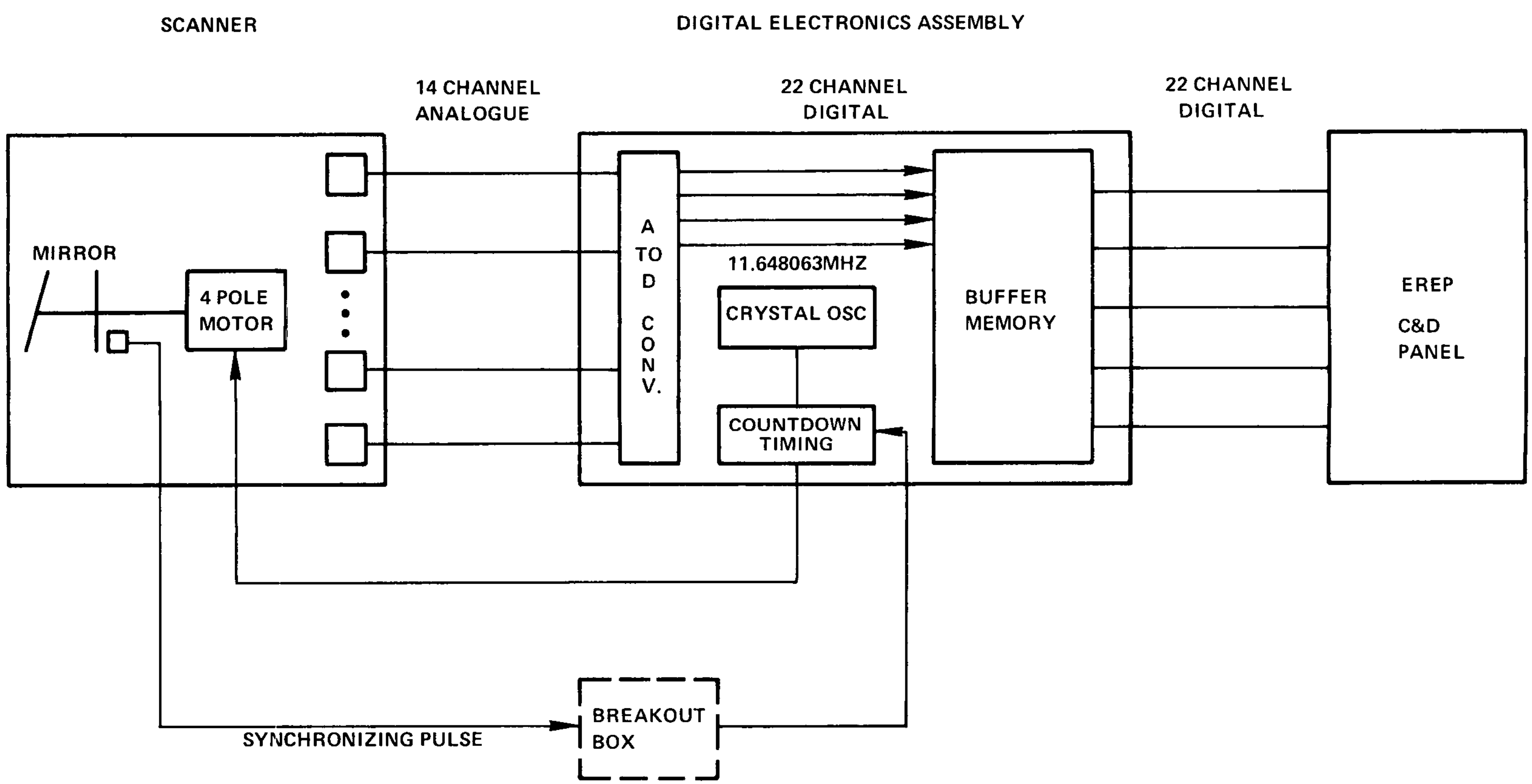

FIGURE 1 - SIMPLIFIED SCHEMATIC

CHANNEL 1

SUB-FRAME 1

WORD	CONTENT
1	SYNC
2	SYNC
3	SYNC
4	SYNC
5	CAL
⋮	⋮
22	CAL
23	DATA
⋮	⋮
128	DATA

SUB-FRAME 2

WORD	CONTENT
1	SYNC
2	SYNC
3	DATA
⋮	⋮
128	DATA

⋮

SUB-FRAME 10

WORD	CONTENT
1	SYNC
2	SYNC
3	DATA
⋮	⋮
128	DATA

FIGURE 2 - OUTPUT DATA FRAME FORMAT

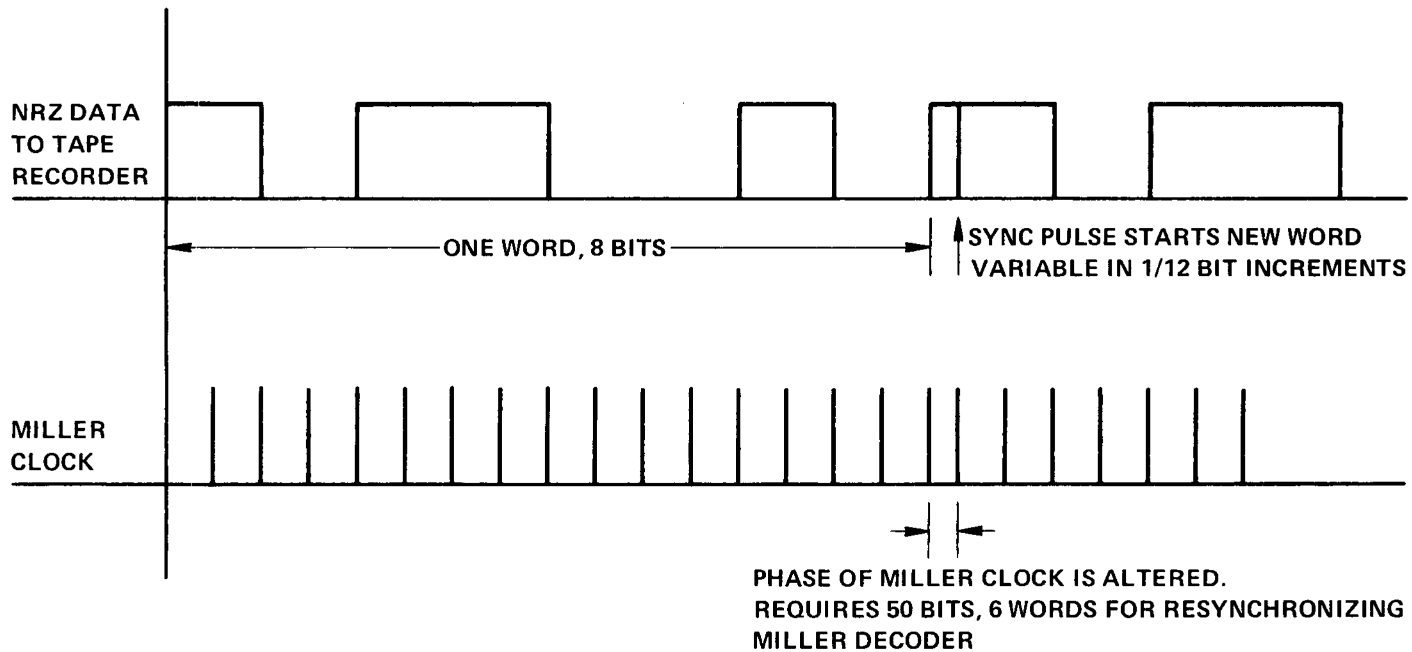

FIGURE 3 - NRZ TAPE RECORDER DATA AND MILLER CLOCK

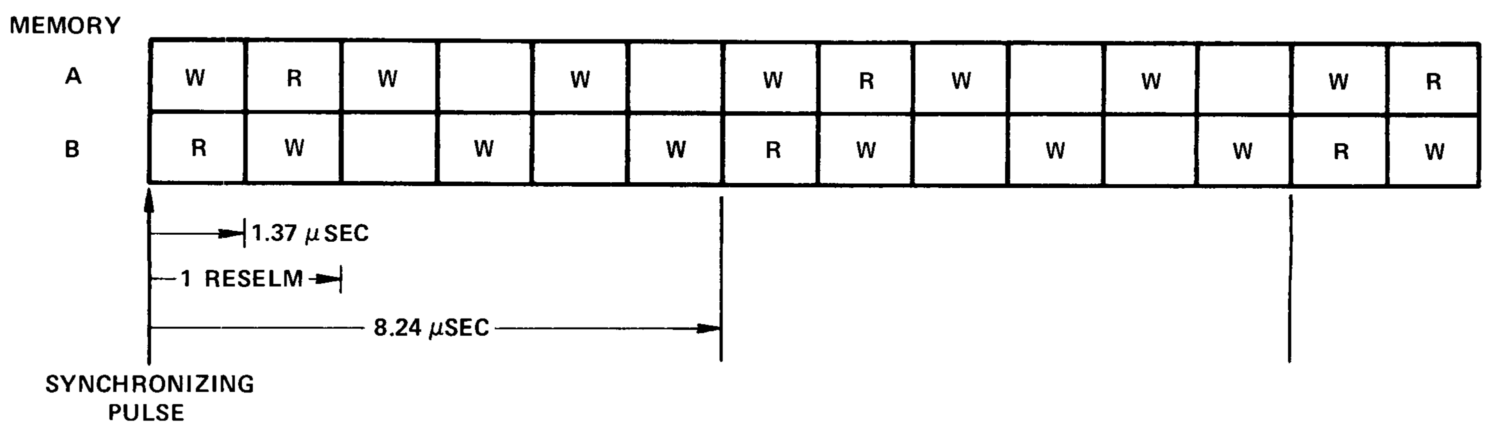

FIGURE 4 - READ — WRITE TIMING FOR A AND B MEMORIES